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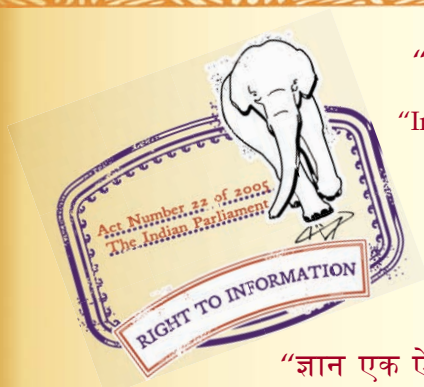
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IS 12730 (1989): Internal fuses and internal overpressure disconnectors for capacitors for inductive heat generating plants [ETD 29: Power Capacitors]



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“Knowledge is such a treasure which cannot be stolen”

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Indian Standard

**INTERNAL FUSES AND INTERNAL
OVERPRESSURE DISCONNECTORS FOR
CAPACITORS FOR INDUCTIVE HEAT
GENERATING PLANTS**

भारतीय मानक

**प्रेरणिक ऊष्मा जनन सयन्तों के सधारिन्तों के लिये आंतरिक पयूज
और आंतरिक अधिदाब वियोजक**

UDC 621'316'923 : 621'316'545 : 621'319'4

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NEW DELHI 110002

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 21 June 1989, after the draft finalized by the Power Capacitors Sectional Committee had been approved by the Electro-technical Division Council.

This standard would help in specifying uniform requirements regarding performance, tests and guidance for coordination of internal fuses and internal disconnector protection of the capacitors for inductive heat generating plants covered in IS 9251 : 1979.

The fuses and disconnectors conforming to this standard are designed to isolate faulted capacitor elements or capacitor units to allow operation of the remaining parts of the capacitor unit and the bank in which the capacitor unit is connected. Such fuses and disconnectors are not a substitute for the switching device such as circuit breaker or external protection of the capacitor bank or part thereof.

This standard is based on the following publication/document issued by the International Electro-technical Commission (IEC):

IEC Pub 594 (1977) and Amendment No. 1 (April 1980) Internal fuses and internal over-pressure disconnectors for capacitors for inductive heat generating plants.

Doc : 33 (Central Office) 72 Draft Amendment No. 2 to IEC Pub 594 (1977).

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

INTERNAL FUSES AND INTERNAL OVERPRESSURE DISCONNECTORS FOR CAPACITORS FOR INDUCTIVE HEAT GENERATING PLANTS

1 SCOPE

1.1 This standard covers the requirements, tests and the guidance for coordination of internal fuses used to protect capacitors for inductive heat generating plants operating at frequencies between 40 Hz and 60 Hz in accordance with IS 9251 : 1979.

1.2 This standard also applies to internal overpressure disconnectors used to protect self-healing metallized dielectric capacitors.

1.3 This standard does not apply to fuses and disconnectors for which service conditions, in general, are incompatible with the requirements of this standard, unless otherwise agreed between the manufacturer and the purchaser.

1.4 The guidance for coordination of fuse and disconnector protection is given in Annex A.

2 REFERENCES

2.1 The Indian Standards listed in Annex B are necessary adjuncts to this standard.

3 TERMINOLOGY

3.0 The following definitions in addition to those given in IS 1885 (Part 42) : 1985 shall apply.

NOTE — The word 'element' in this standard is used in accordance with the definitions contained in IS 1885 (Part 42) : 1985 and not in accordance with IS 9224, IS 9926 or IS 9385.

3.1 Internal Fuse

A fuse connected inside a capacitor unit in series with an element or group of elements.

3.2 Internal Overpressure Disconnector

A disconnecting device inside a capacitor, designed to interrupt the current path in cases of excessive rising pressure.

NOTES

1 This overpressure disconnector is not a current limiting fuse.

2 This type of disconnector can also be placed outside the capacitor unit but it is still considered an integral part of the capacitor unit and shall fulfil the same requirements and pass the same tests as the internal overpressure disconnector.

3 This device is normally used in capacitors of the self-healing type.

2.3 Bank Protection

A general term for all protective equipment for a capacitor bank, or part thereof.

2.4 Unbalanced Protection

A device sensitive to capacitance difference between branches of the bank normally in balance with each other. The capacitance difference may be due to a blown fuse(s) or operation of a disconnector or insulation failure within the bank.

NOTE — Other protective devices, such as overcurrent and earth fault protection, are self-explanatory, since they are commonly used for other applications.

4 GENERAL REQUIREMENTS

4.1 The fuse is connected in series to the element(s). The fuse is intended to isolate if the element(s) becomes faulty. The range of currents and voltages for the fuse is, therefore, dependent on the capacitor design, and in some cases also on the bank in which the fuse is connected.

4.1.1 The operation of an internal fuse is in general determined by one or both of the following factors:

- a) The discharge energy from elements or units connected in parallel with the faulty element or unit, and
- b) The power-frequency fault current.

4.2 The disconnector is intended to interrupt the current to all elements of the capacitor. The proper operation of the disconnector is dependent on the leak-tightness of the container during the life of the capacitor.

5 DISCONNECTING REQUIREMENTS

5.1 The fuse shall enable the faulty element to be disconnected when electrical breakdown of elements occurs in a voltage range, in which U_1 is the lowest, and U_2 the highest (instantaneous) value of the voltage between the terminals of the unit at the instant of fault.

5.1.1 The recommended values for U_1 and U_2 are the following:

$$U_1 = 0.8 \sqrt{2} U_N$$

$$U_2 = 2.0 \sqrt{2} U_N$$

NOTES

1 The U_1 and U_2 values above are based on the voltage that may normally occur across the capacitor unit terminals at the instant of electrical breakdown of the element.

The U_2 values are of a transient nature.

The purchaser shall specify if the U_1 and U_2 values differ from the stated ones. If so, the values stated in 10.1 and 10.4 shall be changed accordingly.

2 The requirements are valid for capacitors switched by a restrike-free circuit-breaker. If the breakers are not restrike-free, other requirements shall be agreed between the manufacturer and the purchaser.

5.2 The disconnector shall enable the faulty capacitor unit to be disconnected for voltage up to and including U_g .

5.2.1 The recommended rms value is:

$$U_g = 1.2 U_N$$

NOTE — The purchaser shall specify if this voltage will be exceeded.

6 WITHSTAND REQUIREMENTS

6.1 After operation, the fuse assembly and the disconnector shall withstand full element voltage and full voltage between the terminals of the disconnected capacitor respectively, plus any unbalance voltage due to fuse or disconnector action, and any short time transient overvoltages normally experienced during the life of the capacitor.

6.2 Throughout the life of the capacitor, the disconnector shall be capable of carrying continuously a current equal to or greater than 1.1 times the maximum permissible unit current, and the fuses capable of carrying continuously a current equal to or greater than the maximum permissible unit current divided by the number of parallel fused paths.

NOTE — The requirements are valid if the capacitors are switched by a restrike-free circuit-breaker. If the breakers are not restrike-free, other requirements are to be agreed between the manufacturer and the purchaser.

6.3 The fuse and the disconnector shall be capable of withstanding the inrush currents due to the switching operation expected during the life of the capacitor.

In addition, the fuse shall be able to withstand continuously 100 switching operations daily as specified in 5.5.6.2 of IS 9251 : 1979.

6.4 The fuse connected to the undamaged element(s) must be able to carry the discharge currents due to the breakdown of element(s).

6.5 The fuses and disconnectors must be able to carry the currents due to short-circuit faults external to the unit(s) on the bank occurring within the voltage range in accordance with 5.1.

7 MARKING

7.1 The marking regarding the presence of internal fuse and internal overpressure disconnector shall be provided on the rating plate of

the capacitor for inductive heat generating plants.

8 TESTS

8.1 Type Tests

The following shall constitute type tests:

- a) Discharge test (see 9),
- b) Disconnecting test on fuses (see 10), and
- c) Disconnecting test on disconnector (see 11).

In addition, the fuses and disconnectors shall be able to withstand all type tests of the capacitor units in accordance with IS 9251 : 1979.

8.1.1 Type tests of fuses are performed either on the complete capacitor unit or, at the choice of the manufacturer, on two units, one unit being tested at the lower voltage limit, in accordance with 10.1 and one unit at the upper voltage limit. The unit(s) shall have passed all routine tests stated in IS 9251 : 1979.

NOTE — Due to testing, measuring and safety circumstances it may be necessary to make modifications to the unit(s) under test; for example, those indicated in Annex C (see also the different test methods given in Annex C).

8.1.2 Type tests of disconnectors are performed on a capacitor unit that shall have passed all routine tests stated in IS 9251 : 1979.

8.1.3 Type tests are considered valid if they are performed on capacitors of a design identical with that of the capacitor offered, or on a capacitor of a design that does not differ from it in any way that might affect the properties to be checked by the type tests.

8.2 Routine Tests

No routine tests are required.

9 DISCHARGE TEST

9.1 The fuses and disconnectors shall be subjected to five discharges within 10 minutes from a dc voltage equal to $2.5 U_N$ through a gap situated as close as possible to the capacitor, without any additional impedance in the circuit.

9.2 To prove that the fuses or disconnectors have not operated, a capacitance measurement shall be made before and after the test, measuring method shall be used that is sufficiently sensitive to detect the capacitance change caused by one blown fuse.

10 DISCONNECTING TEST ON FUSES

10.1 Tests Procedure

The disconnecting test on fuses is performed first at the lower ac test voltage of $0.8 U_N$ and then, as soon as possible after the blowing of one fuse, at the upper ac test voltage of $2.2 U_N$, until the blowing of another fuse.

10.1.1 Certain test methods are indicated in Annex C.

NOTE — If the test is carried out with dc, the test voltage shall be $\sqrt{2}$ times the corresponding ac test voltage.

10.2 Capacitance Measurement

After the test, capacitance shall be measured to prove that the fuse(s) has (have) blown.

10.2.1 A measuring method shall be used that is sufficiently sensitive to detect the capacitance change by one blown fuse.

10.3 Inspection of the Unit

Before opening, no significant deformation of the container shall be apparent.

After opening the container, a check should be made to ensure that:

- a) no significant deformation of sound fuses is apparent; and
- b) not more than one additional fuse (or one-tenth of fused elements directly in parallel) has been damaged (see C-1, Note 1). If method given in C-3 is used a small amount of blackening of the impregnant will not affect the quality of the capacitor.

10.4 Voltage Test After Opening the Container

A voltage test shall be carried out by applying for 10 seconds a dc test voltage equal to 3.5 times the rated voltage of the elements across the broken-down element and the gap in its blown fuse. During the test, the gap shall be in the impregnant. No breakdown over the fuse gap is allowed.

NOTE — For use with all elements in parallel and for all units if test procedure indicated in C-2 or C-3 or C-4 or C-5 is used, this test can be replaced by an ac test before the opening of the unit. The test voltage between the terminals is selected through calculations using capacitance ratio such that the voltage across the breakdown element and the gap in its blown fuse is the above value divided by $\sqrt{2}$.

11 DISCONNECTING TEST ON DISCONNECTOR

11.1 Test Procedure

The capacitor is preheated in a chamber before applying the test voltage until all parts reach a temperature of 60°C. An ac test voltage of 1.6 U_N shall be applied until the disconnector interrupts the current through the capacitor. If the disconnector does not operate within 8 hours, the test voltage is raised to 1.75 U_N .

11.1.1 If, after a further 8 hours, the disconnector still has not operated, the test voltage should finally be raised to 2 U_N , until the current is interrupted. If no interruption is achieved, the temperature may be further raised at the option of the manufacturer.

NOTE — Precautions shall be taken when performing this test against the possible explosion of a capacitor unit.

11.2 Capacitance Measurement

After the test, capacitance shall be measured to prove that the disconnector has operated.

11.3 Inspection of the Unit

Only slight traces of impregnant on the outside of the capacitor are allowed.

11.4 Voltage Tests

A voltage test between terminals shall be carried out by applying, for 10 seconds, an ac voltage equal to 2.15 U_N or a dc voltage equal to 4.3 U_N .

In addition, a voltage test between terminals and container shall be made by applying for 10 seconds the test voltage given in IS 9251 : 1979.

The test voltage shall be applied after the capacitor has cooled down to room temperature.

11.4.1 No internal breakdown is allowed.

NOTE — The current shall be recorded during the test.

ANNEX A

(Clause 1.4)

GUIDE FOR COORDINATION OF FUSE AND DISCONNECTOR PROTECTION

A-1 GENERAL

A-1.1 The fuse is connected in series with the element that the fuse is designed to isolate, if the element becomes faulty. After the breakdown of an element, the fuse connected to it will blow, and isolate it from the remaining part of the capacitor, which allows the unit to continue in service. The blowing of one or more fuses will cause voltage changes within the bank, when series connection is used.

A-1.2 The voltage across sound unit(s) must not exceed the value given in IS 9251 : 1979.

A-1.3 Depending on the internal connection of the units, the blowing of one or more fuses may also cause a change of voltage within the unit.

The remaining elements in a series group will have an increased working voltage, and the manufacturer shall, on request, give details of the voltage rise caused by blown fuses.

A-1.4 A typical arrangement of internal overpressure disconnectors in a three-phase unit can be seen in Fig. 1.

In Fig. 2, the operational principle of the internal overpressure disconnector can be seen.

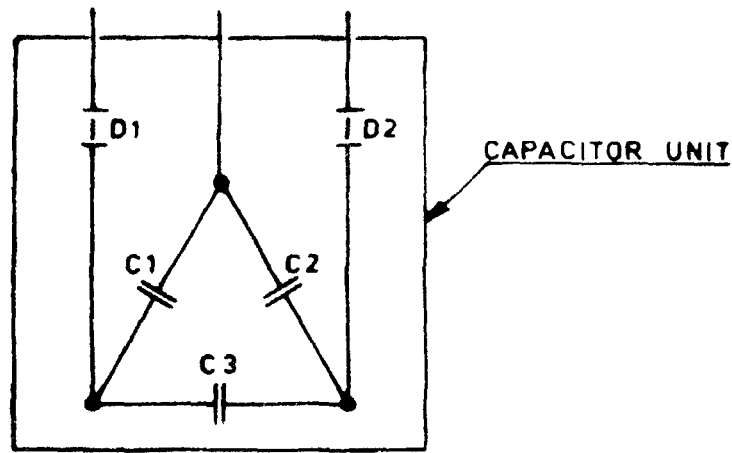
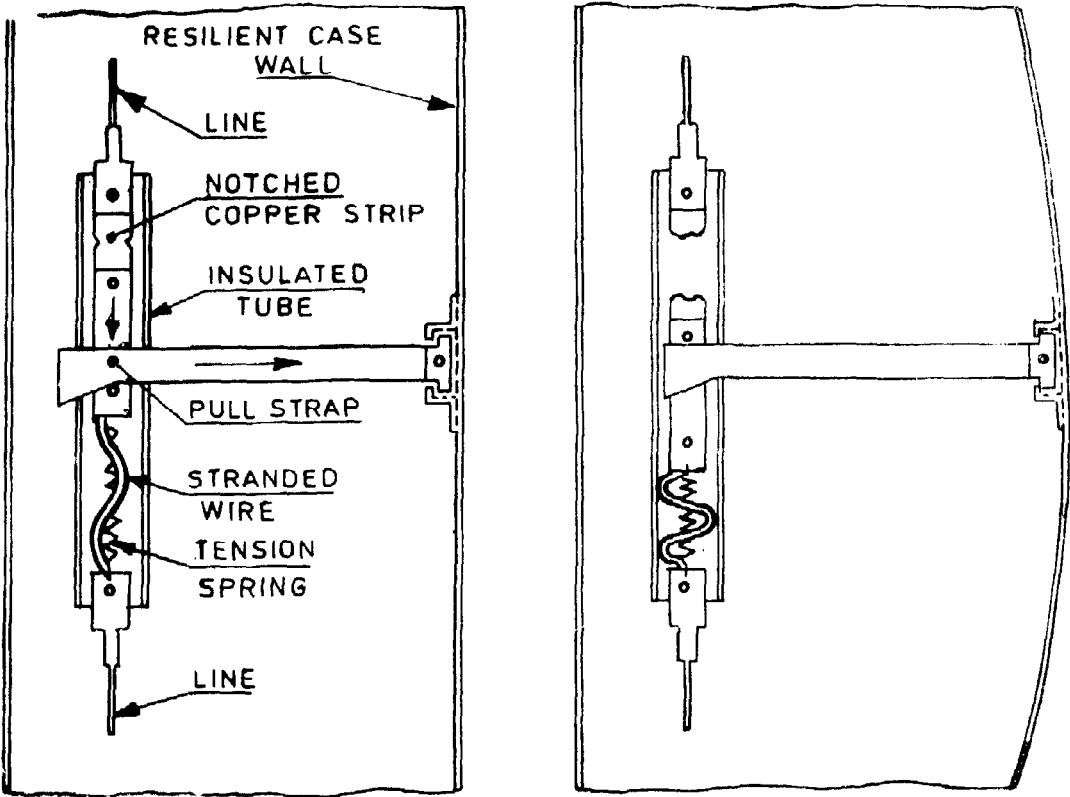


FIG. 1 TYPICAL LAYOUT OF A THREE-PHASE DELTA-CONNECTED CAPACITOR UNIT, WITH TWO INTERNAL OVERPRESSURE DISCONNECTORS (D_1 AND D_2)



2A Disconnecter Before Operation

2B Disconnecter After Operation

NOTE — In the event of rising pressure, a resilient wall of the container bulges out. By movement of the pull strap, the notched copper strip is torn into two sections. By the action of the tension spring, the current is interrupted and the arc is extinguished very quickly, because the disconnecter is installed in an oil-filled insulating tube.

FIG. 2 PRINCIPLE OF DESIGN FOR AN OVERPRESSURE DISCONNECTOR FOR SELF-HEALING MEDIUM VOLTAGE POWER CAPACITORS

Because of the self-healing properties of the capacitor, breakdowns are not dangerous and do not increase the current significantly. But, in the event of rising pressure (for example, caused by thermal instability, which may occur at the end of the life of the capacitor, or, in some cases, by an excessive number of self-healing breakdowns, caused by extreme overloads) the self-healing power capacitor should be protected by an internal overpressure disconnecter.

A-2 PROTECTION SEQUENCE

A-2.1 The protection of a capacitor bank must operate selectively. The first step is the fusing of

the element(s) or the operation of the disconnecter. The second step is the relay protection of the bank (for example, overcurrent or unbalance protection). The third step is network or plant protection.

NOTES

1 Depending on the output of the bank, the design of the relay protection, etc, all the three steps are not necessarily used in all capacitor banks.

2 In large banks, an alarm stage may also be used.

3 Unless the fuse always blows as a result of discharge energy within the voltage range in 5.1, the manufacturer shall provide the current/time characteristic and tolerances of the fuse.

ANNEX B

(Clause 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	Title	IS No.	Title
IS 1885 (Part 42) : 1985	Electrotechnical vocabulary: Part 42 Power capacitors (<i>first revision</i>)	IS 9385	Specification for high voltage fuses
IS 9224	Specification for low voltage fuses	(Part 1) : 1979	Part 1 Current limiting fuses
(Part 1) : 1979	Part 1 General requirements	(Part 2) : 1980	Part 2 Expulsion and similar fuses
(Part 2) : 1979	Part 2 Supplementary requirements for fuses for industrial applications (<i>superseding</i> IS : 2208)	(Part 3) : 1980	Part 3 Application guide for high voltage fuses
(Part 4) : 1980	Part 4 Supplementary requirements for fuse-links for the protection of semiconductor devices	(Part 4) : 1983	Part 4 Determination of short - circuit power factor for testing of high voltage fuses
IS 9251 : 1979	Specification for capacitors for inductive heat generating plants operating at frequencies between 40 and 24 000 Hz	(Part 5) : 1983	Part 5 Types and dimensions of fuse-links for current - limiting fuses
		IS 9926 : 1981	Specification for fuse-wire used in rewirable type electric fuses up to 650 volts

ANNEX C

[Clauses 8.1.1, 10.1.1, 10.3(b) and 10.4 (Note)]

TEST PROCEDURES FOR THE DISCONNECTING TEST ON INTERNAL FUSES

C-1 GENERAL

C-1.1 One of the test procedure given in C-2, C-3, C-4, C-5, C-6, or an alternative method, shall be used.

C-1.2 If no agreement has been reached, the choice is left to the manufacturer (see also Note under 8.1.1).

NOTES

1 At the upper voltage limit, one additional fuse (or one-tenth of the fused elements directly in parallel) connected to a sound element(s) is allowed to be damaged.

2 The test voltage shall be maintained for few seconds after a breakdown, to ensure that the fuse has disconnected correctly, unaided by disconnection of the power supply.

3 In special cases, it may be necessary to extend the tests until two or more breakdowns of capacitor elements have occurred. The number of breakdowns at each voltage limit shall in such cases be subject to agreement between the manufacturer and the purchaser. If the number of breakdowns is exceeded, the voltages stated in 10.4 may have to be increased.

4 To verify the current limiting behaviour of the fuses when tested at the upper voltage limit, the voltage drop, excluding transient, across the blown fuse must not exceed 30 percent.

5 If the fuse does not fulfil the requirement of Note 4, precautions must be taken to make certain that the parallel stored energy, and the power frequency fault current available from the system, are representative of service conditions.

A test shall then be made to demonstrate satisfactory operation of the fuse.

6 Precautions shall be taken when performing this test against the possible explosion of a capacitor unit and the explosive projection of the nail.

C-2 CAPACITOR PREHEATING

C-2.1 The capacitor unit is preheated in a chamber before applying the ac test voltage at the lower limit. Preheating temperature (100°C to 150°C) is chosen by the manufacturer to achieve a practical short time (few minutes to few hours) to the first breakdown.

C-2.2 A lower preheating temperature should be used when applying the test voltage at the higher voltage limit, to avoid breakdowns before reaching the test voltage.

C-2.3 Capacitor current is to be recorded during the test.

NOTE — To prevent excessive internal liquid pressure due to high temperature, the unit may be equipped with a relief tube including a valve which must be closed at the instant of applying the test voltage.

C-3 MECHANICAL PUNCTURE OF THE ELEMENT

C-3.1 Mechanical puncture of the element is made by a nail, which is forced into the element through a pre-drilled hole in the container. The test voltage may be dc or ac, the choice being left to the manufacturer.

C-3.2 If ac voltage is used, capacitor current is to be recorded during the test and timing of puncture should be made, to ascertain that the breakdown is triggered to take place at the instant of the peak of the ac test voltage, or very near to it.

NOTES

1 Puncture of only one element cannot be guaranteed.

2 In order to limit the possibility of a flashover to the container along the nail, or through the hole caused

by the nail, the punctures may be performed in the elements connected, permanently or during the test, to the container.

3 DC voltage is especially suitable for capacitors having all elements in parallel.

C-4 ELECTRICAL BREAKDOWN OF THE ELEMENT (FIRST SOLUTION)

C-4.1 Some elements in the test unit are each provided with, for example, a tab, inserted between the dielectric layers. Each tab is connected to a separate terminal.

C-4.2 The test voltage may be ac or dc, the choice being left to the manufacturer.

C-4.3 To obtain breakdown of an element thus equipped, a surge voltage of sufficient amplitude is applied between the tab and one of the foils of the modified element.

C-4.4 In the case of ac voltage, the surge must be triggered at the instant of the peak or very near to it.

C-4.5 Capacitor current is to be recorded during the test.

C-5 ELECTRICAL BREAKDOWN OF THE ELEMENT (SECOND SOLUTION)

C-5.1 Some elements in the test unit are each provided with, for example, a short fuse wire connected to two extra tabs and inserted between the dielectric layers. Each tab is connected to its own bushing.

C-5.2 The test voltage may be dc or ac, the choice being left to the manufacturer.

C-5.3 To obtain breakdown of an element equipped with this short fuse wire, a capacitor charged to a sufficient voltage is connected to the two bushings connected to it in order to explode the wire.

C-5.4 In the case of ac voltage, the connection of the charged capacitor causing the wire explosion must be triggered at the instant of the peak voltage or very near to it.

C-5.5 Capacitor current is to be recorded during the test.

C-6 ELECTRICAL BREAKDOWN OF THE ELEMENT (THIRD SOLUTION)

C-6.1 A small part of an element (or some elements) in a unit is at the time of manufacture removed and replaced with a weaker dielectric for example, 0 to 20 cm² of a film-paper film dielectric is *punctured* away and the hole is covered with two thin papers.

This method will require experience on how to make a suitable dielectric strength reduction.

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Doc : No. ETD 29 (2977)

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at Saini Printers, Delhi, India